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Forestry Research West

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A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

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Entomologist Barbara Bentz, Intermountain Station, collects samples of mountain pine beetle larvae from a lodgepole pine tree. Scientists are investigating how the tiny but devastating insect survives winter cold. Read about it beginning on page 1.

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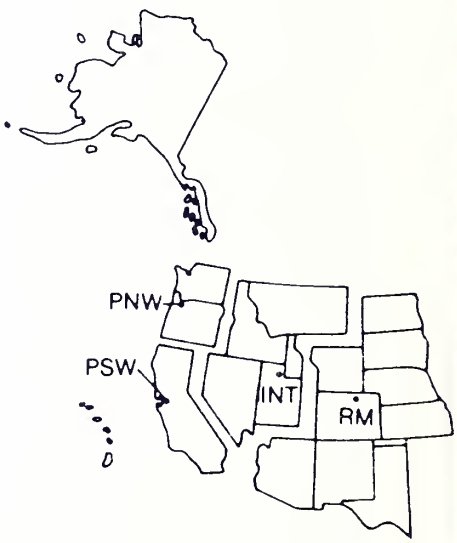


MPB may use "antifreeze" to survive the cold

by Cindy Chojnacky
Intermountain Station

The work has meant frozen fingers, long treks on snowshoes and four trips a month to three states to visit lodgepole pine stands infested with mountain pine beetle. But researchers at the Intermountain Station's Logan Forestry Sciences Lab have gained new insights into how the tiny but devastating insect yearly survives winter cold, emerging each summer to attack and kill pine trees throughout the West.

The research is part of a long-term project to model mountain pine beetle phenology — the beetle's survival strategy or process it uses to synchronize its life cycle with environmental conditions. If researchers know how environment affects the insect's life cycle, they can predict beetle population trends — giving resource managers a better handle on when and where beetle epidemics may occur.

The mountain pine beetle *Dendroctonus ponderosae* Hopkins is both an economically serious pest and a critical component of western forest ecosystems, according to Mountain Pine Beetle Project Leader Jesse Logan.

To collect the sample, Logan inscribes a circle, carefully removes the bark, and then collects beetle larvae from the phloem beneath.

Infrequent mountain pine beetle outbreaks can affect large land areas. For instance, more than 4 million acres per year were infested in the West between 1979–1983, killing more than 15 million trees a year. However, the beetle is also a natural part of forest ecosystems and has helped shape their scale and pattern. The mountain pine beetle project is building on 32 years of research to assess the insect in its broader ecological context.

As part of this assessment, Entomologist Barbara Bentz is learning how temperature drives mountain pine beetle development. This is a key part of the tiny insect's strategy in its continual war against the pine tree. The beetle infests green trees, constructs vertical egg galleries, and lays eggs in the phloem, where its young will live and grow. The network of galleries ultimately girdle a tree, killing it by cutting off flow of nutrients and water from its roots.

The tree's aim is to spit out the invaders. A vigorous tree will expel or "pitchout" beetles with a copious flow of resin.

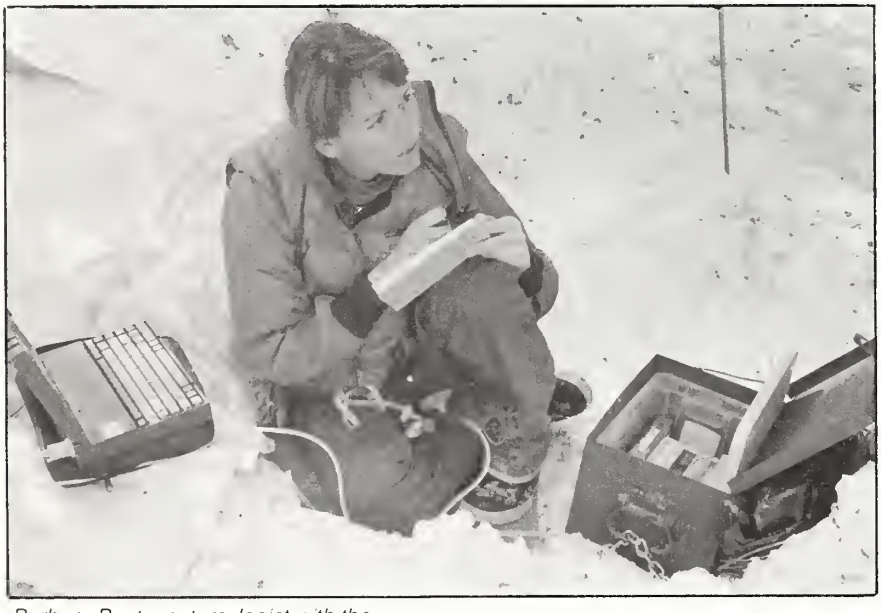
A key weapon for the beetle is synchronous emergence — the ability of adult beetles to emerge within a short time period, regardless of when they started their life cycle the previous fall. "This is crucial for the successful attack by a small, weak predator (beetle) on a large dangerous prey (pine trees)," says Logan.

But how do they do it? Temperature seems to be the key factor driving phases of the beetle's life cycle. At lower elevations in the West, that cycle is a year long.

The cycle

It usually starts in early August, when mature adult beetles emerge from their host trees, fly, attack live trees, and begin building new galleries and laying eggs. At higher elevations, however, because of colder temperatures, the mountain pine beetle life cycle can take up to 2 years.

Oviposition (egg-laying) of new brood may last as long as two months, depending on the onset of cooler fall temperatures.



Barbara Bentz, entomologist with the Logan Forestry Sciences Laboratory Mountain Pine Beetle Project, huddles in the snow as she records mountain pine beetle data.

Somehow, the lifestages synchronize development so that by the time the brood has developed to the adult stage the following August, the mature adults are ready to emerge within a 3–4 week time span. Bentz, Logan and past Project Leader Gene Amman hypothesize that inherent temperature thresholds in the different lifestages help in this synchronization. Ongoing research is testing this hypothesis.

Beetles progress through five different stages: eggs, larvae, pupae, brood adult and parent adult. Larvae hatch in fall and further develop from September–June through four stages called instars. The length of time spent in each instar is dependent upon temperature. Bentz' dissertation work involved developing a computer simulation model to predict the temperature-development relationship. The winter surveys are part of work to validate the model by comparing larval development to temperatures in its environment.

The project started in July 1992. Four sites close to beetle-infested lodgepole where chosen near Victor, Idaho; two sites in the Sawtooth National Recreation Area in Idaho; and one in Logan Canyon, Utah. Five to ten trees were baited with a synthetic pheromone that attracts beetles.

After beetle flight, the researchers monitored beetle colonization of the trees and placed temperature probes in the phloem on the north and south side of each tree. The probes provide hourly temperature readings. "We measure phloem temperatures, the environment where the beetle lives, every hour for its entire life cycle," says Bentz. This past year a new experiment was initiated on the Dixie National Forest, where mountain pine beetle infest ponderosa pine.

To monitor beetle development, Bentz has visited each site monthly to sample larvae over the past two years. Biological Technicians Lynn Rasmussen and Jim Vandygriff usually help. At times, even Project Leader Logan accompanies the crew and freezes his fingers, too. For each sample, they cut out a circle of bark, extract the live eggs, larvae, pupae and adults and place them in alcohol. Back at the lab, insects are placed under a microscope and measured. "The only way you can determine what larval instar they are in is to measure the width of the headcap which changes as they molt from one instar to the next," explains Bentz.

"Although many researchers have studied the beetles, no one had ever sampled them in their natural environment in the middle of winter before," Bentz says. "It's hard to. Here you are, out in the snow, your fingers freezing, holding a knife and tweezers in your teeth, trying to scrape larvae into a vial. It's a slow, cold process."

Success at last

But the cold has been worth it. Bentz has discovered how pine beetle larvae and adults winter over in the phloem of lodgepole trees, surviving temperatures as low as -35 degrees Centigrade.

For insects, a common winter survival strategy is diapause — kind of a mini-hibernation triggered by lower temperatures or shorter days (photo period). Other insects escape to warmer areas. The mountain pine beetle does not have a known diapause, and Bentz has found the larvae, which remain in the phloem, are often in an environment as cold as the air temperature in the stand. These beetles are obviously not escaping the extremes of winters in the West. Instead, it seems the mountain pine beetle's strategy is chemistry. "The insect produces a chemical sort of like 'antifreeze' " Bentz explains. Lowered temperatures apparently prompt the insect to synthesize a polyol (e.g. glycerol) that keep its tissues from freezing at temperatures well below 0 degrees C. This cold-hardening process is complex and depends on the rate, duration and intensity of exposure to cold temperatures.

Detailed studies to help understand this process are planned for this fall. David Gray, a scientist at Virginia Polytechnic Institute and State University (VPI&SU), cooperated with the researchers to build specialized cold temperature cabinets. The cabinets will be used to test the response of beetle lifestages to varying rates of temperature change, intensity, and duration, and their ability to cold-harden. Don Mullins, also at VPI&SU, is helping to identify the compounds used by the mountain pine beetle to survive the long cold periods in western lodgepole pine.

"Conventionally, people have thought that mortality was highest in the mid-winter," Bentz says. "I think more mortality occurs in the spring and fall when you have the most extensive phloem temperature fluctuations, as high as 30–40 degrees in a day." Sudden changes in temperature do not give the beetles adequate time to metabolize the necessary chemicals.

This information on when and how mortality occurs will also be added to Bentz' phenology model.

Temperature seems to be a driving force in pine beetle population responses year-round. The past 2 summers have been extremes, in terms of weather. Last year was cold and rainy, while this year it is hot and dry.

Bentz scales a ladder for the cold, arduous task of collecting larvae.

The beetles have responded accordingly. They flew much later in 1993; this year, they flew early. "The beetles are responding to these extreme conditions and it's exciting to be measuring their response," Bentz says.

The phenology model has both management and research applications. For instance, managers could use such predictions in the Bridger-Teton National Forest in western Wyoming, where trees are beetle-infested in campgrounds along the Snake River. "Managers are wondering if they need to spray, but they don't want to because the area is also eagle habitat. If the model predicts a lot of mortality, for instance, they may not need to spray. Or it may show where and when they need to spray.

"Predicting actual population numbers may be unrealistic, but we hope to be able to predict trends — whether the population is going up or down," adds Bentz. "Also, the phenology model is allowing us to test research hypotheses on the long term role of the mountain pine beetle in the forest ecosystem."

Canopy crane enhances ecosystem research

by Sherri Richardson
Pacific Northwest Station

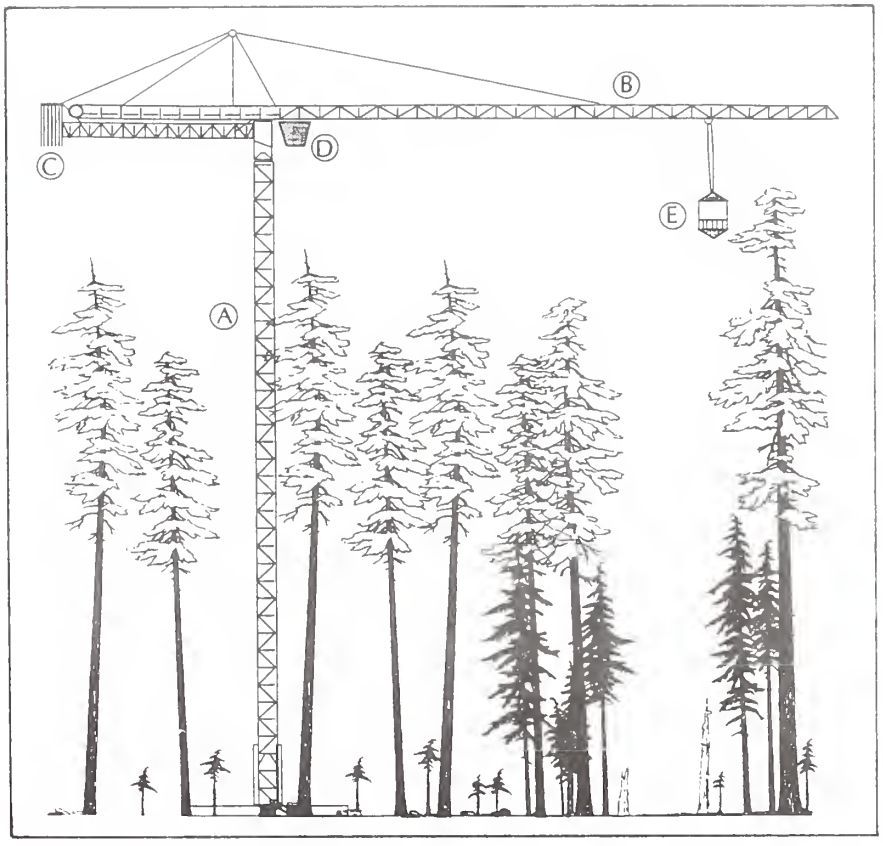
In February 1992, two scientists from the Pacific Northwest Station — Cathy Rose and Martin Raphael — spent 10 days with a team of researchers deep in the hot, humid rain forests of Panama and Costa Rica to observe the operational aspects of several canopy access systems. They were particularly interested in a crane installation used by the Smithsonian Tropical Research Institute — a pioneer in the use of construction cranes for canopy research.

The visit to the rain forests also was the first step in the development by the Station and the University of Washington of a similar project in the old-growth forests of the Northwest — making it the second of two such structures in the world.

When Forest Ecologist Rose first went up in the gondola of the crane high above the tree tops in the Panama City park where the crane is located, she called it a sensory experience. "You are up there with the birds and suddenly you are seeing things from their perspective. You see monkeys and all kinds of wildlife you never see on the ground. Researchers in the tropics who were the first to go up in the trees were so surprised about what they found — many species they had never even known existed. It was as if people finally understood what the word biodiversity really meant."

Wildlife Biologist Raphael used the word "fantastic" to describe the first time he went up in the gondola. "The experience struck me as a marvelous way to view a canopy with minimal disturbance, basically, without touching anything. It was an unmatched opportunity."

The 80-foot-high apparatus Rose and Raphael were referring to is patterned after a tower crane typically used in building construction. The crane has a gondola that scientists can work inside of that will lower them to almost any location in a 2-hectare arc of the forest. The researcher can then observe the uppermost branches of trees to study the broad variety of life that lives in the canopy. The scientist can be raised and lowered from within the gondola by signaling to an operations technician controlling the crane.



Forest Canopy Crane. (A) tower, (B) load jib, (C) counter-balance jib, (D) operator's cab, (E) gondola. Illustration Robert Van Pelt.

Examining crane operations in Panama and Costa Rica

The 1992 Trip that Rose and Raphael participated in also included Jerry Franklin, former PNW researcher and now an ecologist at the University of Washington and the prime mover behind launching the $1 million canopy crane project in the Pacific Northwest; Gordon Smith, David Shaw, and Dean Berg of the Olympic Natural Resource Center; and Robert Szaro, Forest Environment Research, Forest Service, Washington Office.

Franklin first got the idea of using a crane system in the Pacific Northwest about 4 years ago while attending a meeting in Denver on global climate change. Present at the meeting were scientists from the Smithsonian Tropical Research Institute who shared information about the project. "I was very excited about using the crane here and immediately followed up on the idea by contacting several Congressmen who were equally enthusiastic," recalled Franklin. "The crane will open up whole new areas of research and any knowledge [about the forest] can only by helpful." The crane will belong to the University of Washington, and Franklin will be the principle investigator for the research.

During the Costa Rica and Panama trip Franklin participated in, the team observed the pros and cons of several canopy research systems used by scientists in the tropical rain forests.

- Fixed towers — employs scaffolding stairs; disadvantage is that this allows observation from only one point of the canopy
- Rope systems — employs climbing ropes installed at fixed points; disadvantage is this causes disturbance to plants and other forms of life
- Ladder systems — employs a ladder mounted on a tree; disadvantage is ladder allows access to only one spot

The team also visited a canopy research site in Monteverde, Costa Rica, in which several large trees had been installed with the rope system. "We all took turns wearing climbing harnesses and ascending ropes using specialized devices," Raphael explained. "I certainly appreciated the advantages of crane-based access after this experience!"

Installation of canopy crane in Pacific Northwest underway

For the past 3 years, the Pacific Northwest Research Station, in partnership with the University of Washington, has been working on finding a site for a 300-foot-tall steel and concrete crane for research in the old-growth forests of the Northwest. In June 1993, a site was finally found in Skamania County, Washington, in the Wind River Experimental Forest, which is part of the Gifford Pinchot National Forest.

According to Project Coordinator John Henshaw, the site was selected by scientists for its "excellent example of old-growth forests and the close power supply at the Wind River Nursery needed to operate the crane."

The road to the recently signed memorandum of understanding among county officials, the Station, and the University of Washington was not a smooth one, however. Two sites, Forks and Quinault, Washington, also were considered before the Wind River location was selected. "Project planners changed their minds about Forks because the area was not thought to have the key elements the scientific community believed were necessary to complete the project," Henshaw explained.

"And in Quinault, residents feared the research could lead to more restrictions on timber harvest. The community had been hard hit by logging restrictions resulting from protection of the northern spotted owl and other endangered species, and so some residents viewed the crane as one more block or hindrance to the welfare of the economy of their community."

During the process of site selection, the Forest Service held several public meetings to present the concepts and benefits of the crane and to hear how residents felt about it. The Forest Service took the position of respecting the wishes of residents and nixed locations that did not meet with public approval. Finally, in June 1994, the project was presented to the residents and officials of Skamania County and the project was approved. "The residents of the county understood that the research was simply for learning more about old-growth forests and they also realized the financial benefit to their community," said Henshaw.

"The crane is a significant research tool for scientists because it will expand our knowledge base of the forest canopy — which is very limited," added Henshaw. "A significant deterrent to conducting canopy research has been the difficulty accessing the canopy — especially reaching branch tips and hoisting heavy measuring instruments. The crane eliminates those problems. The crane also will reap financial benefits for the community. Congress has allocated money for the project, and the Forest Service and the University of Washington also have committed funds. This will be a world-class research site that will bring more dollars to a community hard hit by the reduction in the timber cut."

A trained operator sits in the cab and communicates with researchers in the gondola via voice or hand-held two-way radios.

Why is it important to study the forest canopy?

The forest canopy is a key element to biodiversity. It represents the two layers of the forest where a large portion of functions important to forest productivity and health take place (the upper soil layer is the other). The canopy also is the home for birds, insects, and other forms of wildlife and plant life. Therefore the canopy research will focus in some of the following areas:

- Photosynthesis and water use in big, old trees
- Vertical stratifications of animals, including distribution and behavior

- Validating canopy structure predictions from remote sensing data
- Linking canopy structure to ecosystem function
- Micrometeorological studies including measurement of gaseous, dry and wet deposition

Other topics identified by scientists affiliated with the project include community studies relating to forest productivity and health, and predicting vegetation changes likely from global climate change.

The crane project at Wind River has a team of senior scientists who will review proposals for research and the project will be evaluated after 5 years. The site also will have an interpretive plan to help the public access the information developed. Periodic tours for schools and other groups will permit visitors to better understand the research taking place.

The gondola is screened with hinged windows because of dangers from stinging insects. The bags hanging outside the gondola contain seat harnesses and ropes for descent to safety in case the gondola malfunctions.

Canopy crane symposium kicks off planning

The use of canopy cranes for the study of the ecosystem is a hot topic in research circles. In March 1994, about 300 scientists from Mexico, Canada, and the United States gathered in Ellensburg, Washington, for the 67th Northwest Scientific Association meeting. The meeting, held at Central Washington University, featured a symposium, "Northwest Forest Canopies: Biology, Ecology, and Silviculture." The symposium, sponsored by the Pacific Northwest Station, the College of Forest Resources at the University of Washington, and the Canopy Institute, was one of many meetings and networks established for the intent of learning more about what has largely been a mystery to researchers.

"The symposium," said Cathy Rose, who helped coordinate the event, "was a kickoff to get research planning off the ground for the proposed crane." Rose will coordinate the activities of the PNW canopy research team along with partners taking over from John Henshaw, who has moved on to a new assignment at PNW. The Wind River crane is expected to be operating in fall 1994.

For more information regarding the project, contact Cathy Rose, Pacific Northwest Station, Bend Silviculture Laboratory, 1027 NW Trenton Avenue, Bend, Oregon 97701.

Methods of cutting study has unexpected benefits

by Louise Mastrantonio
for Pacific Southwest
Station

A research project begun more than 50 years ago in northeastern California is today providing information for a purpose far different than that for which it was first intended.

The study, conducted at Blacks Mountain Experimental Forest, northwest of Susanville in the Lassen National Forest, was designed to help evaluate timber harvest methods for the eastside pine type. This important commercial forest region covers some 2.3 million acres and extends east of the Cascade and Sierra Nevada Ranges from British Columbia south as far as Baja California. The principal species in this forest type in northeastern California include ponderosa pine, Jeffrey pine, California white fir, and incense-cedar. Species composition varies locally and by elevation with white fir and incense-cedar being more common at high elevations.

Typical stand of eastside pine on the Blacks Mountain Experimental Forest.

Silvicultural questions

In 1937, when the study was begun, the main forestry goal for the region was to maximize timber production. With this study, called the methods-of-cutting study, researches hoped to gather information that would help answer the basic silvicultural questions of the time: what to expect in the way of annual growth, what the annual "allowable cut" should be, and what would be the best timber harvest methods—whether even-aged (clearcutting) or different intensities of uneven-aged management (selection cutting).

For the study, 20-acre plots were established for each treatment. These included no treatment, clearcutting, and three different levels of selection cutting: heavy selection (removing approximately 75 percent of the volume), moderate selection cutting (approximately 55 percent cut), and sanitation salvage (removing only trees prone to insect damage). The study was installed over a 10-year period from 1938–1947 in old-growth stands at Blacks Mountain.

The goals of the study were to determine what cutting methods would produce the most wood and which would best reduce mortality associated with bark beetles. Early on, results indicated that sanitation salvage would produce the best results — both to maximize wood production and to reduce beetle damage. After ten years, however, the data pointed to heavy cutting as a better alternative. The idea is that younger trees grow more quickly than older ones, add wood faster, and consequently produce more harvestable timber in a given amount of time. Also, young trees are less vulnerable to insect attack. The study was instrumental in developing what became the generally accepted forestry practice for the eastside pine type: clearcut "overmature" stands, and use a light "improvement cut" to accelerate growth in others.

New directions

Today, however, the management goal for National Forest timberlands has changed considerably. While public foresters may still want timber harvest as a goal, the emphasis has shifted to ecosystem management with timber harvest as a by-product of good forest management. This means managing the forest for long-term productivity and for multiple resources.

In this "new" forestry, providing good wildlife habitat is as important a goal as timber production and maintaining old-growth conditions as important as rapid wood production.

Somewhat surprisingly, because the old methods-of-cutting study pointed the way toward clearcutting and even-aged management, that study is now being used as an information source for old-growth management.

In the late 1980's, PSW Station scientists at Redding began to get interested in the Blacks Mountain study again. One of their research problems at the time was to evaluate alternatives to even-aged silviculture. Because Blacks Mountain still had quite a few areas of old-growth timber left, and the old methods-of-cutting study was still in place, scientists "dusted off" the old data base and began a new study there.

Fifty years of data

During the field seasons of 1990 and 1991, the old plots were remeasured under the direction of Bill Oliver, project leader at Redding. Altogether over 27,000 trees were measured. Diameter was measured for all trees. Height, not measured in the original study, was also measured for every tenth tree. Researchers also noted any dead trees and checked for damage that might have occurred since the previous measurements: top breakage, damage by lighting, wind breakage, animal damage, or other sources. If the tree was a snag, researches also recorded its height, stage of decay, and the number of nest holes found in it.

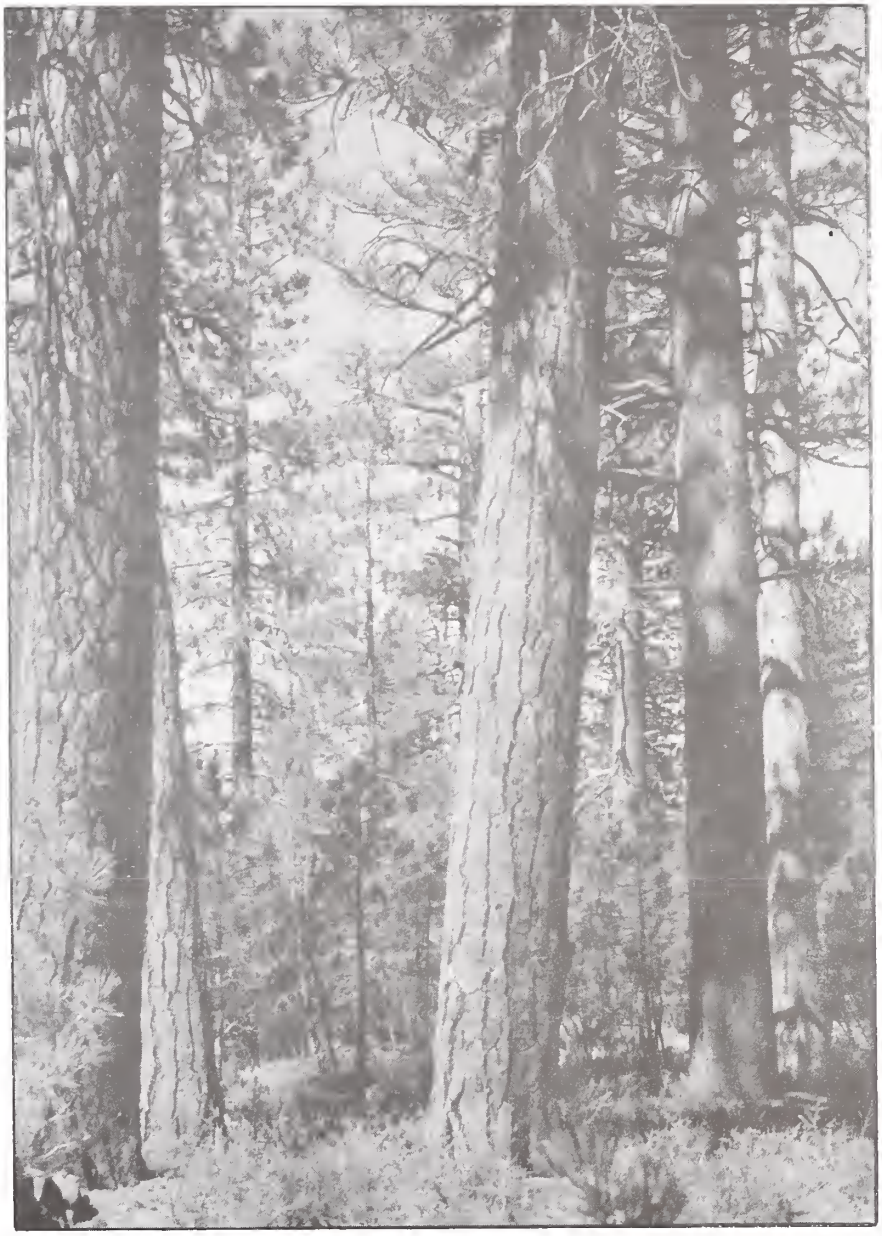
Results

Three findings are important from the 1990 study:

- Diameter growth rate of remaining trees increased with increasing intensity of harvest. This means that the heavier the timber harvest, the faster the remaining trees grew in the years since cutting. For example, in plots where approximately 75 percent of the overstory was removed, pines (Jeffrey and ponderosa) grew at an average rate of about .075 to .125 inches a year compared to only about .03 to .09 inches a year in the control plots (no cutting). Other species, including white fir and incense-cedar, followed that same trend.

- Average net wood volume (volume of wood cut at original harvest, plus the standing volume after 50 years, after deducting for mortality), was highest for the plots that had been clearcut. That is, if wood production was the main goal, clearcutting would be the best method of harvest. Total wood volume produced was lowest for the control plots — those plots that had not been cut at all. Total yield was not statistically different for any of the plots harvested at high levels, whether 55, 75, or 95 percent.

- Over the years, there was no significant change in species composition on any of the plots. Only pole-size trees were evaluated, however, and Leroy Dolph, a research forester at Redding, believes some species changes might have been observed if seedlings had been included in the evaluation.



Grove of old-growth ponderosa and Jeffrey pine in one of the 20-acre control plots (no treatment) of the methods-of-cutting study.

The main benefit for forestry today, according to Dolph, is knowing the growth rates of individual trees over long time periods. "With this type of information, managers can project the type of wildlife habitats that will be created in stands cut to different densities," he says. For example, it is especially important to know how soon trees begin to assume old-growth characteristics. The growth studies provide specific information on that. And, managers can project how long it will take for a stand to grow trees from about 20 inches in diameter to 40 inches.

And the study points out the necessity for on-going management, even for old-growth forests. You can't just "do nothing," Dolph maintains. "Without management, you're going to reduce growth, create an unhealthy forest that is susceptible to disease, insects, and create build-up of fuels that are a fire hazard. In addition, wood production will fall off."

Unique data base

The Blacks Mountains methods-of-cutting may be the oldest and largest data base for growth and yield of eastside pine throughout its range. Having this long-term record is important, according to Dolph. "The only other way to get the same information would be to increment core every tree and analyze past rates of growth." That would be much too time-consuming and costly."

New 50-year study

Researchers are now building on the data base with a new 50-year study at Blacks Mountain. This study is interdisciplinary in nature and is headed by Kathy Harcksen, a forester in the silviculture work unit at Redding. The goal is to determine how vegetation and wildlife respond to different intensities of forest management. Treatments, to begin in 1995, will include the creation of old-growth forests with high structural diversity, forests with low structural diversity, and other treatments such as grazing and prescribed fire.

The study is in line with the PSW Station's long-range research plan that includes ecosystem studies as one of six areas of research emphasis. As part of the Blacks Mountain study, researchers will be able to evaluate a multitude of ecosystem functions under different management or cutting intensities. Some of those functions include:

- Numbers and species diversity of small mammals, birds, amphibians, and reptiles
- Soil fertility processes
- Carbon budget responses
- Factors related to long-term productivity, including the role of wildfire
- Vegetation establishment and growth responses
- Changes in genetic and biological diversity
- Entomological relationships, especially bark beetles
- Pathogen response

The 50-year baseline information from the methods-of-cutting study is a unique and valuable legacy and a major reason for locating the new interdisciplinary study at Blacks Mountain Experimental Forest. Besides the opportunity to work in relatively undisturbed forests, the new study will build on a foundation of five decades of vegetational response to various intensities of timber harvest.

Can we sustain SW aquatic habitats and fishes?

by John Rinne and
Rick Fletcher
Rocky Mountain Station

Historically, riparian areas of the Southwest have been home to several rare native fishes such as the Gila and Apache trouts, Colorado Squawfish and bonytail and humpback chubs. However, these vital habitats and the native fishes they supported have declined markedly due to dam construction, water diversion, channelization and groundwater mining. Many species could not adapt to these impacts, leading to a dramatic decline in the native fish fauna. Some species even became extinct. Although the extent of these biological and hydrological alterations has slowed, their legacy persists.

Today, a group of scientists with the Rocky Mountain Station's research lab in Flagstaff, AZ, are coordinating extensive research and management efforts to help curb this dramatic loss of habitat and fishes, and to reverse its trend.

Research Fish Biologist John Rinne explains, "The native fish fauna in streams in the arid Southwest is 'poverty-stricken' compared to that of drainages in the East. Endemism is high in fishes in the Southwest, and specialization of forms is the rule."

From the most diminutive endangered pupfish to the largest known minnow in the world, the Colorado squawfish, the fishes in the Southwest comprise an endangered fauna

In addition to water projects, the progressive depletion of native fishes has also resulted from introductions on non-native fishes. Many species were introduced largely for recreational or sport fishing; some were introduced accidentally. As a result, the fish fauna of Arizona has almost tripled since 1900. Today, 60 percent of the native fishes in the Southwest are listed by federal and state agencies as threatened, endangered or of special concern.

Hydrologic impacts

Over the years, the hydrology of the Southwest has been altered dramatically. In Arizona alone, 80 percent of mainstream river habitats have either been physically and chemically altered or completely lost through drying. In the late 1800s, more than a dozen native fishes swam in the waters of the Salt River near Tempe. Now, only an assemblage of introduced species such as carp, catfish, sunfishes and cyprinids from the bait industry can be collected in the few remaining artificial aquatic habitats created by gravel mining, developments and sewage effluent.

Similar to the Salt, the Gila River dried following completion of Coolidge Dam. The Gila topminnow and desert pupfish once abounded in these waters, and the large Colorado salmon, or squawfish, once ran in spawning schools. These once extensive and diverse aquatic habitats are now rivers of sand characterized only by intermittent of subsurface flow.

The abrupt, remarkable walls of the Grand Canyon attest to the powerful erosional forces of the once untamed Colorado River. The river is now controlled and extensively modified by a half dozen mainstream dams.

Another instance is the taming of the Colorado River, which began in 1935 with Boulder Dam impounding Lake Mead. Again, successive dams below and above this initial structure completely controlled and altered this highly diverse and hydrologically variable aquatic habitat.

Watershed impacts

Other impacts have come from the upper elevation forests of central Arizona which have been extensively harvested and grazed, resulting in increased erosion and siltation. In addition, the post-war westward movement of people, combined, with the 1960 Multiple Use and Sustained Yield Act, brought about increased use of our national forests through hunting, fishing and general recreational activities — all increasing the disturbance to these already fragile ecosystems.

"Often," says Rinne, "the concepts of the intimacy of watersheds and their use, and the functioning and health of riparian/stream systems and the disciplines of hydrology and fisheries were not fully realized."

Aravaipa Creek, in Arizona, sustains 7 of the original 17 native Gila River Basin fish species. Presently, two of these are threatened and four are candidate species for federal listing.

Biological impacts

Another major impact on native fishes was, and continues to be, hybridization with introduced species. Rainbow and cutthroat trout were first introduced around the turn of the century. Because of its spring spawning habits, the rainbow freely hybridizes with the native Apache trout. As a result, the Apache has been reduced drastically in range and numbers. The native trout is now found in less than 5 percent of its former range in Arizona. The massive range reduction of the Apache trout can also be attributed to habitat alteration and competition with brown and brook trouts.

However, progress is being made. Much of the hybridization that occurred between Apache and rainbow trouts is diminishing with the cessation of stocking of fingerling rainbow trout. In addition, the combination of either using "catchables" or the prohibition of stocking of rainbow trout in steams containing native trout and the apparent innate genetic trait have dampened the historic, more extensive hybridization effect.

A final negative factor facing native trouts is competition with non-native fishes for food and space. Laboratory experiments show that adult brook trout are more aggressive than Apache trout, and can interfere with feeding and spawning. For instance, one study shows that the red shiner, a "habitat generalist," typically becomes abundant and dominates many fish assemblages in midwestern streams. This dominance usually occurs to the detriment of more specialized fishes. Today, the red shiner is widespread in aquatic habitats of the Southwest, and scientists believe it has contributed significantly to the decline of native fish populations in that region.

"Evidence of the importance of predation on natives by introduced fishes is increasing," says Rinne. "For example, studies show that rainbow trout have a significant impact on the native Little Colorado spinedace, and the green sunfish appears to be replacing the native Gila chub. In addition, the drastic decline of the razorback sucker in the lower Colorado River has been attributed in part to predation by catfish. Finally, the mosquitofish, labeled the 'fish destroyer,' introduced worldwide as a biological control agent for mosquito larvae, has drastically reduced the range of the native Gila topminnow."

Current lab experiments at the aquatics lab in Flagstaff are demonstrating the significance of introduced predatory trout on young Apache trout and the Little Colorado spinedace — both federally threatened species.

Conservation efforts

Serious efforts to conserve native fishes in North American deserts began in the late 1960's and early 1970's — all based on the National Environmental Policy Act of 1969, the Endangered Species Preservation and Conservation Acts of 1966 and 1969, and ultimately the 1973 Endangered Species Act. They laid the legislative groundwork to conserve and sustain all threatened and endangered species and their habitats. In the Southwest, conservation efforts are normally outlined in multi-agency recovery plans that include objectives and activities aimed at securing, maintaining and enhancing habitats. These activities may involve removal of non-native fishes with piscicides (chemicals designed to kill fish). "However," says Rinne, "the success of habitat renovation can be reduced due to size and/or complexity of habitat, lack of habitat security through ownership or special management, variable conditions of habitats from year-to-year, and the ever-present threat of introduced species." Rinne notes the need to move from protection and listing of native Southwestern species to active recovery.

"Large-scale rearing of fishes in hatchery environments, coupled with intensive, long-term re-introduction into what is deemed 'favorable habitat' in the wild, also has been used extensively in conservation efforts," he says. "Several extensive re-introductions of razorback sucker into un-renovated streams and rivers in Arizona have failed largely because of predation by non-native species."

He says that purchase and management of riparian/stream habitats by private agencies such as The Nature Conservancy have been a boon to desert fishes.

"Improving aquatic habitat though instream improvements has become a common practice for recovery of salmonids. However, because such instream, site-specific improvement is often conducted without regard to surrounding land use and resultant condition of the supplying watersheds, the probability of failure increases," says Rinne.

The sustainability question

The bottom line — "Can native Southwestern fishes and their habitats be sustained?" In part the answer lies in 1) securing habitats, 2) species management strategies, and 3) ecosystem or landscape, versus project or target, management of natural resources.

"First," says Rinne, "we must undertake conservation activities where the habitat is relatively secure, and where we can reasonably be most effective. Acquisition of large, important habitats and numerous riparian/stream areas has been, and will continue to be, critical to sustaining native fish species. Recent land exchanges by the USDA Forest Service are prerequisite to sustaining native fishes in the wild, and special designation and management of riparian/stream areas are both timely and critical. Finally, cooperative interagency management that is synergistic in recovering species and sustaining biodiversity in our streams and rivers should be adopted. Multi-disciplinary approaches incorporating hydrologists, biologists, geneticists, geologists and botanists that address the overall ecosystem, or biodiversity philosophy of conservation, must also be formulated.

"Secondly, too often, past management and conservation efforts for native desert fishes were undertaken under crisis situations and were narrowly focused and monospecific in nature. Conservation of desert fishes must consider diversity of the fauna and begin to move away from single-species management toward ecosystems or groups of species. Successful strategies for sustaining native fishes must include the multitude of fish species that are becoming rare but are not yet federally listed," he says.

Rinne and his associates believe that managers and researchers that consider such candidate, vulnerable, restricted, sensitive, or special species are becoming more proactive. For example, in the Southwest Region of the Forest Service (NM and AZ), there are more than 230 sensitive vertebrate species, 15 of which are fishes. "Unfortunately," says Rinne, "much endangered species management and research has adopted a 'flagship' philosophy, wherein budgeting and efforts are directed toward a few high-profile species such as the bald eagle, grizzly bear, whooping crane and spotted owl. Although flagship efforts may indirectly spill over and affect other species needing immediate conservation attention, this is a serendipitous, but less desirable, way to manage ecosystems. Through timely conservation we can increase the probability that many of these species will never be listed as threatened or endangered. Further, if we design our conversation efforts on an ecosystem basis, a greater number of species in need of help will automatically be addressed.

"To be successful, such a philosophy necessitates a multi-agency and multi-disciplinary approach," he says. "That is, the broader the landscape a recovery or conservation plan addresses, the greater the probability that more than one agency will be involved in management. Equally important, the probability is greater that a larger component of total fish diversity, rather than single, indicator or threatened and endangered species, will be addressed.

Both education and involvement of the public at the earliest possible age play an essential role in sustaining the endangered southwestern fish fauna.

"Great strides have been made in understanding the issues of conservation and perpetuation of biodiversity of fishes in the Southwest since enactment of the Endangered Species Act," Rinne concludes. "It behooves us to adopt innovative approaches in future conservation efforts for this regional fish fauna. It is time to move from 'saving' native fishes to 'recovering' and sustaining them in their native habitats. We have come far, yet have far to go. Only if the overall aquatic and related resources are given priority in our conservation efforts will aquatic habitats and native fish biodiversity be maintained for perpetuity."

For more information on this research, contact John Rinne, Southwest Forest Science Complex, 2500 S. Pine Knoll, Flagstaff, AZ 86001, (602) 556-2181, FAX (602) 556-2130. Copies of a reprint that describe these studies are available from the Rocky Mountain Station. Request *Declining Southwestern Aquatic Habitats and Fishes: Are They Sustainable?*

New from research

Root dipping doesn't beat the heat

Foresters have experimented many years with root dipping—coating the root systems of bareroot seedlings with a water-holding or growth-stimulating substance before planting. Root dipping in vermiculite and water mixture became a standard step in planting preparation for sites in the Intermountain Region, Forest Service, starting in the early 1970s. Root dipping is supposed to help moderate the harsh conditions on Intermountain planting sites, noted for their hot, dry climate during the summer months.

Research Forester John Sloan recently compared several root dips on lodgepole, Douglas-fir and Engelmann spruce seedlings. The studies took place in the growth chamber, greenhouse and in the field. Effects varied with species, soil type and type of root dip. Under dry conditions, root dipping did not improve shoot growth, root growth, or survival. With proper handling of conifer planting stock, avoiding root exposure to drying elements, root dipping is not necessary, the author maintains.

For more details on Sloan's methods and findings, request Research Paper INT-476, *Root Dipping of Conifer Seedlings Shows Little Benefit in the Northern Rocky Mountains*. It's available from the Intermountain Station.

Handbook for monitoring landbirds available

A new publication by Dr. C.J. Ralph et al. compiles methods that can be used to assay population size, demographics, and status of many species of birds occurring in a wide variety of habitats. Useful anywhere in the New World, the publication discusses several methods, including four types of censuses for determining population size and trends, mist-netting and nest searchers to determine demographic parameters, and other methods that will be useful in operating a monitoring station, including habitat and weather observations, and suggestions for training personnel and possibilities for detailed studies. For a copy of *Handbook of Field Methods for Monitoring Landbirds*, General Technical Report PSW-144, contact the Pacific Southwest Station.

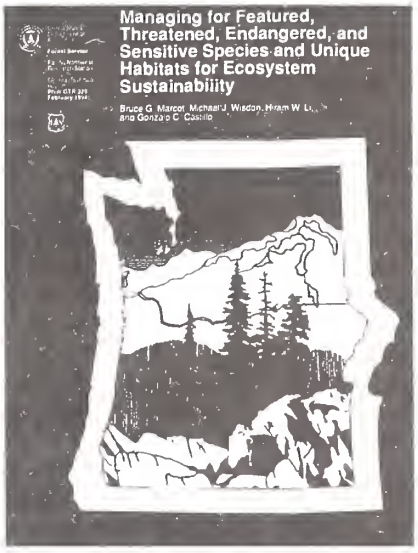
Evaluation changes in plant communities

The procedure for evaluating plant community change using the squared Euclidean distance (SED) resemblance function is discussed in a recent paper by Raymond Ratliff and Sylvia Mori. Authors point out that this method, which uses common statistical methods, gives a confidence interval for the expected change and facilitates the interpretation of results. Use of the confidence interval for the difference of the intracluster and intercluster means with analyses of species, provides for early detection of community change. However, it is still the manager's job to decide whether a statistically significant change is biologically significant and whether action to fine-tune management should be taken. For a copy of this publication, contact the Pacific Southwest Station and request *Squared Euclidean Distance: A Statistical Test To Evaluate Plant Community Change,* Research Note PSW-416.

Managing for ecosystem sustainability

The traditional approach to wildlife management has focused on single species—historically game species and more recently threatened and endangered species. New approaches to managing for multiple species and biological diversity include managing coarse filters, ecological indicator species, indicator guilds, and use of species-habitat matrices.

Such modeling approaches each have strong as well as weak points, including conflicts among objectives for species with disparate needs. This publication presents three case examples of integrating management for single species with management for multiple species and ecosystems; managing elk habitat in the Blue Mountains of eastern Oregon; managing for sustainable native fish faunas in eastern Oregon and Washington; and managing plant and animal species closely associated with old-growth forests in the Pacific Northwest.



Request *Managing for Featured, Threatened, Endangered, and Sensitive Species and Unique Habitats for Ecosystem Sustainability,* General Technical Report PNW-329, from the Pacific Northwest Research Station.

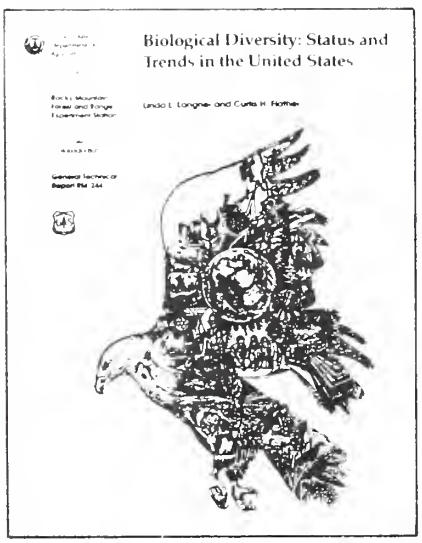
Photographic guide to riparian forage utilization

Riparian area impacts by cattle and other large grazing animals are a great concern to range managers. Managers, who often must survey large areas, need a quick and easy method for estimating forage utilization in riparian areas.

Range Technician John W. Kinney and Botanist Warren P. Clary (also project leader, Riparian-Stream Ecology and Management work unit) have just developed the first-known photographic guide to estimate percent utilization for riparian plant species. The guide is based on the grazed-class method, which provides visual comparison standards with estimates based on the growth form of the plant rather than its size. An appendix includes photos and height-weight curves for nine riparian herbaceous forage species in the Intermountain area.

A Photographic Utilization Guide for Key Riparian Graminoides, General Technical Report INT-308, is available from the Intermountain Station. Another tool for riparian area management, also from the Station, is *Field Guide to Intermountain Rushes,* General Technical Report INT-306.

RPA documents now available



The Forest and Rangeland Renewable Resources Planning Act (RPA) requires periodic (10-year) assessments of the condition of, and future for, the Nation's natural resources. A series of publications are being produced by Forest Service scientists and cooperators that provide a mid-cycle (5-year) update on natural resource issues. These publications are designed to help policymakers make important resource management decisions.

Publications available so far are: *U.S. Forests in a Global Context,* General Technical Report RM-228. It summarizes world forest resource data as of 1990; *Regional Demand and Supply Projections for Outdoor Recreation,* General Technical Report RM-230. It lists regional recreation supply and demand projections; *Effects of Subdivision and Access Restrictions on Private Land Recreation Opportunities,* General Technical Report RM-231. This publication reviews the effects of subdivision and access restriction on recreation potentials and use; *Technology Change and the Economics of Silvicultural Investment,* General Technical Report RM-232. It describes financial analyses of intensive and low-cost reforestation options for two predominant timber types in the U.S. — loblolly pine and Douglas-fir.

Other available publications are: *Forest Resources of the United States, 1992,* General Technical Report RM-234. Resource tables present estimates of forest area, volume, mortality, growth, removals and timber products; *Private Forest Investment and Softwood Production in the U.S. South,* General Technical Report RM-237. In this publication, a capital accounting approach is used to measure the net effects of land area change, forest type conversion, and direct investment on timber assets in the southern U.S. from 1952 to 1992; *Species Endangerment Patterns in the United States,* General Technical Report RM-241. Authors discuss why they think the single-species approach to conserving threatened and endangered species in the U.S. is insufficient. They also offer recommendations; *Recycling and Long-range Timber Outlook*, General Technical Report RM-242. This report provides an analysis of long-range trends in paper recycling and impacts on the timber industry; *Biological Diversity: Status and Trends in the United States,* General Technical Report RM-244.

Biological diversity in the U.S. is summarized in three categories: genetic diversity, species diversity and community/ ecosystem diversity; *Effect of Management on Water Quality in North American Forests*, General Technical Report RM-248. This paper discusses how some management practices can seriously impair stream water quality.

These listed reports are currently available from the Rocky Mountain Station. There are seven additional papers planned for publication within the next year. They will cover such subjects as the future demand for outdoor recreation, impacts of state and local regulations on the private timber supply, global change, historic resource trends, and minerals and water quality. These upcoming publications CANNOT be ordered or reserved at this time. They will, however, be announced in a future issue of *Forestry Research West*.

United States
Department of
Agriculture

Forest Service

**Rocky Mountain
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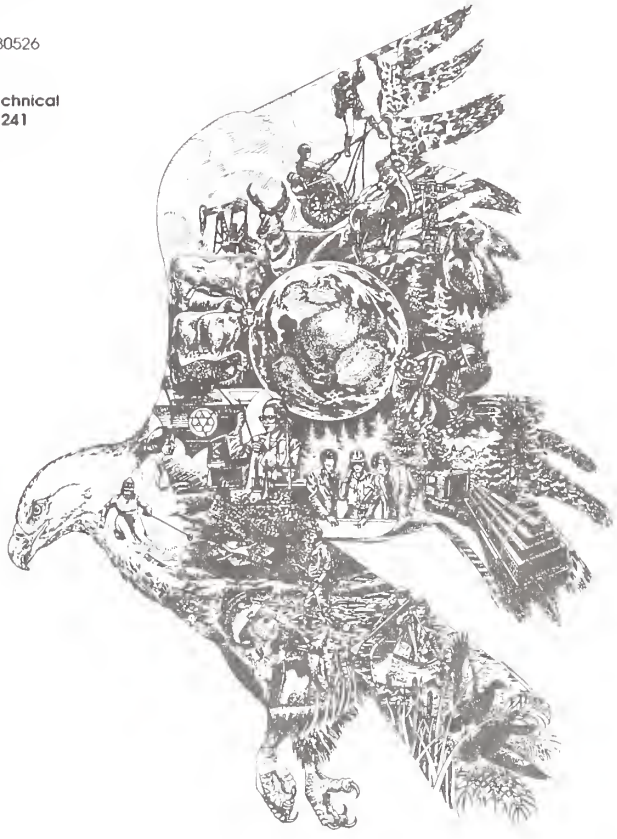
**General Technical
Report RM-241**

Species Endangerment Patterns in the United States

Curtis H. Flather, Linda A. Joyce, Carol A. Bloomgarden



Effects of shrub removal on *Abies concolor* growth reported

PSW Scientists Susan Conard and Steven Sparks recently reported their findings from a study in the northern Sierra Nevada. The two revisited two sites to assess the responses of naturally regenerated *Abies concolor* saplings to vegetation recovery 8–9 years after release treatments. They found that the treatments had caused major and persistent shifts in vegetation structure and composition on both sites. They also found that differences in individual tree growth within treatments were strongly correlated with structure and composition of neighboring vegetation, even where no treatment effects were observed. The great variability in response between sites illustrates the strong effect of site characteristics on response to release treatments and the importance to managers of anticipating such differences before making treatment decisions. For more information on this study, contact the Pacific Southwest Station and request Abies concolor *Growth Responses to Vegetation Changes Following Shrub Removal, Northern Sierra Nevada, California*, Research Paper PSW-218.

Maps show daily growth of 1988 Greater Yellowstone fires

In summer, 1988, the Greater Yellowstone Area experienced the most extensive forest fires seen in the Western States since the great Northwest fires of 1910. A new publication displays the growth of the 1988 fires using daily fire growth maps, processed with a geographic information system (GIS). The fire record integrates data from daily infrared photography flights, satellite imagery, ground and aerial reconnaissance, command center intelligence, and the personal recollections of fire observers.

Using GRASS GIS software, fire position was digitized from topographic maps to construct a file of daily fire location in vector format. The vector file was converted to raster format for further analysis. The data base is available in electronic form. A summary of the fire growth and points of interest throughout the summer is included.

Request *Fire Growth Maps for the 1988 Greater Yellowstone Area Fire,* General Technical Report INT-304, available from the Intermountain Station.

Guide for studying salmon underwater

Fisheries biologists who need reliable censuses of salmonid populations in streams of the Intermountain West will benefit from this new guide on underwater observation techniques. The guide outlines procedures for using snorkeling gear in estimating fish abundance, the size structure of populations, and habitat use. It also provides criteria for identifying fish underwater.

Behavior of target fish species, physical habitat attributes and other factors can bias results, warns Author Russell F. Thurow. This guide will help biologists identify and account for potential biases and encourage a standarized procedure in using underwater techniques to survey salmonids in streams. It addresses the principal resident and anadromous salmonids found in the Intermountain West.

For a copy of *Underwater Methods for Study of Salmonids in the Intermountain West,* request General Technical Report INT-307, July 1994, from the Intermountain Station.

To order any of the publications listed in this issue of *Forestry Research West*, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

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2) RPA documents (list title and General Technical Report No.)

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3) *A photographic Utilization Guide for Key Riparian Graminoids,* General Technical Report INT-308.
4) *Field Guide to Intermountain Rushes,* General Technical Report INT-306.
5) *Root Dipping of Conifer Seedlings Shows Little Benefit in the Northern Rocky Mountains,* Research Paper INT-476.
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1) *Squared Euclidean Distance: A Statistical Test to Evaluate Plant Community Change,* Research Note PSW-416.
2) *Handbook of Field Methods for Monitoring Landbirds,* General Technical Report PSW-144.
3) *Visitor Perceptions of Crowding and Discrimination at Two National Forests in Southern California,* Research Paper PSW-216.
4) *Abies concolor Growth Responses to Vegetation Changes Following Shrub Removal, Northern Sierra Nevada, California,* Research Paper PSW-218.
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Martins, sables and fishers: biology and conservation

The first comprehensive book on martins, sables, and fishers was recently published by Cornell University Press. PNW Station Wildlife Biologist Martin Raphael was one of four editors that worked on the book.

The book, *Martens, Sables, and Fishers*, provides a look at a group of carnivores largely characterized by their dependency on wilderness habitat, and vulnerability to human encroachment and overharvesting for their valuable fur.

The fisher and the American marten, like the northern spotted owl, also are strongly tied to the conservation of late-successional forests in North America.

Thirty chapters, written by specialists from eight countries, range from reports of original data to unique reviews and syntheses of previous data. With coverage that spans the Northern Hemisphere, the book offers information on evolution, population ecology and management, conservation, habitat ecology and management, and physiology and reproduction. The book will be a valuable resource for zoologists, wildlife biologists, natural resource managers, ecologists, biogeographers, foresters, and evolutionary biologists.

Raphael edited the book along with Steven Buskirk (Associate Professor of Zoology and Physiology, University of Wyoming), Alton Harestad (Associate professor of Biology, Simon Fraser University), and Roger Powell (Associate Professor of Zoology, North Carolina State University, Raleigh).

Martins, Sables, and Fishers, is available from Cornell University Press, Sage House, 512 East State Street, Ithaca, NY 14850. It also can be ordered by phone by calling (607) 277-2338. The hardcover volume is $60.

Perceptions by ethnically diverse visitors of crowding and discrimination

To research hypotheses on racism and displacement, visitors on two National Forests in southern California were studied regarding their perceptions about such seemingly diverse topics as types of activities most enjoyed on wildland recreation sites, crowding, evidence of discrimination, and displacement. Activities enjoyed and perceived crowding were similar among four racial and ethnic groups: Anglo-Americans, Hispanic Americans, Mexican Americans, and all others. The biggest difference among the groups was perceived exposure to discriminatory acts, which were reported more often by minority groups. Research needs and management implications involve improving interactions and communication with visitors, reducing depreciative behavior, and posting better signs. Contact Pacific Southwest Station for a copy of *Visitor Perceptions of Crowding and Discrimination at Two National Forests in Southern California*, Research Paper PSW-216.

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